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AN EXAMINATION OF APPLICATIONS OF REMOTE SENSING DATA TO METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS' PLANNING REQUIREMENTS

by

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ABSTRACT

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ABSTRACT:

A comprehensive inventory of a series of applications to which remote sensing data may be beneficially applied for use in a variety of regional planning programs of concern to the Metropolitan Washington Council of Governments has been undertaken in this study. Examples of application, methods for data utilization and corresponding photographic illustrations are provided illustrating how remote sensing would prove particularly useful as a unique and/or supplemental data source.

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1. INTRODUCTION

This study is one of a group of research tasks undertaken as a part of the Metropolitan Washington Council of Governments' series of investigations into the potential applications of remote sensing data for use in support of urban and regional planning information requirements. The project is conducted under contract with the Geographical Applications Program, U.S. Geological Survey. The goal of the project is to investigate how remote sensing can be used to improve COG's data collection programs, to improve the usefulness of the information base, to support analytical techniques, and to assess whether its use can reduce the cost of data collection. (MWCOG proposal).[12] It is recognized that remote sensing data alone will not solve our urban problems or even supply all of the data required to address the problems. However, it is apparent that remote sensing can provide important inputs to an urban information system, which in turn, can be used as a base for the solution of some of these urban problems. (Alexander, p. 890).[1]

An organization such as the MWCOG devotes a great deal of its resources to providing information in the form of reports and studies to those local elected and appointed officials who must make the decisions concerning the welfare and development of the region. The information is of no use, however, unless it is accurate and current and can be focused effectively on the problems at hand. Current efforts to provide this information are often difficult, complex, time-consuming and costly operations which involve acquisition, interpretation and summarization, and updating from sources such as planning agencies, building and tax assessment records, other local government departments, utility companies and special authorities and others. (MWCOG Proposal).[12]

The value of remote sensors as an urban data source is frequently underestimated by those who have much use for it. As Bowden has noted, "Few planning and adminstrative groups are using remotely sensed data to any extent and very few have plans for future use. While the researchers give lip service to application of developed techniques, the potential users exhibit a reluctance to convert or integrate remote sensing into present programs. (Bowden, p. 364).[3] It is to demonstrate the practical uses to which remote sensing data may be put that this Council of Governments' research effort is concerned.

Other reports in this series of studies have been directed to an analysis of specific areas of remote sensing data application, viz., land use, urban change detection, housing quality, and so on. This report discusses in a broad summary approach, data needs related to a variety of problem areas of planning concern in the metropolitan Washington area, to which remote sensing information may be put.

2. APPLICATIONS

The programs of the Metropolitan Washington Council of Governments are both numerous and varied, dealing with subjects as diverse as water quality and sources of supply, and traffic behavior. Remote sensing cannot supply data for all of the Council of Governments' programs and projects, but the amount of data it can supply is impressive. The applications mentioned in this report could, for the most part, also be applied to other urban areas of similar size and complexity, making modifications for the applicable local environment and conditions as required.

A. Natural Features

Basic to the development of the region is knowledge of the natural features of the area. Natural features obviously influence the direction and patterns of urban growth. Witness the effects upon growth of such factors as rivers and streams barriers, and other features such as hills, flatlands and lowlands. Although the effects of natural features upon growth in the Washington region are not always generally appreciated nor apparent, they still exist. Neglect of consideration of these features during the development process has often proven short-sighted and costly. For example, areas of severe slope or areas subject to flooding are often unsuitable for most types of development and therefore are best channelled by controlled usage into recreation, scenic land, open space or undeveloped areas. Pertinent data for planning purposes concerning the physical aspects of the region should include current information on geology, soils, flood plains, severe slopes, drainage systems, resource areas, and so on. Remote sensing can provide data in varying degrees on all of these features.

(1) The application of remote sensing to geology is a well established and wide spread practice in government and industry for producing geologic maps and for providing additional knowledge in support of field operations. A wide variety of sensors, including color and infrared photography, thermal imagery and radar, are available which can be applied to the task. Use of these in the Washington area, however, would probably be best suited to providing a unique view of the area's geologic features to agument existing geological maps of the region.

Side Looking Airborne Radar (SLAR), for example, provides regional geologic data not readily visible from ground surveys. Figure 1 presents an example of the type of geologic structure and topographic detail visible on radar imagery. A drawback of the existing geologic maps might also be corrected. With current imagery as a data source, existing geologic maps could be updated and adjusted to more appropriate scales for metropolitan facilities planning. (Natural Features, p. 46).[14] However, in areas where no adequate geologic maps exist, remote sensing data can provide a relatively rapid means of acquiring extensive geologic data.

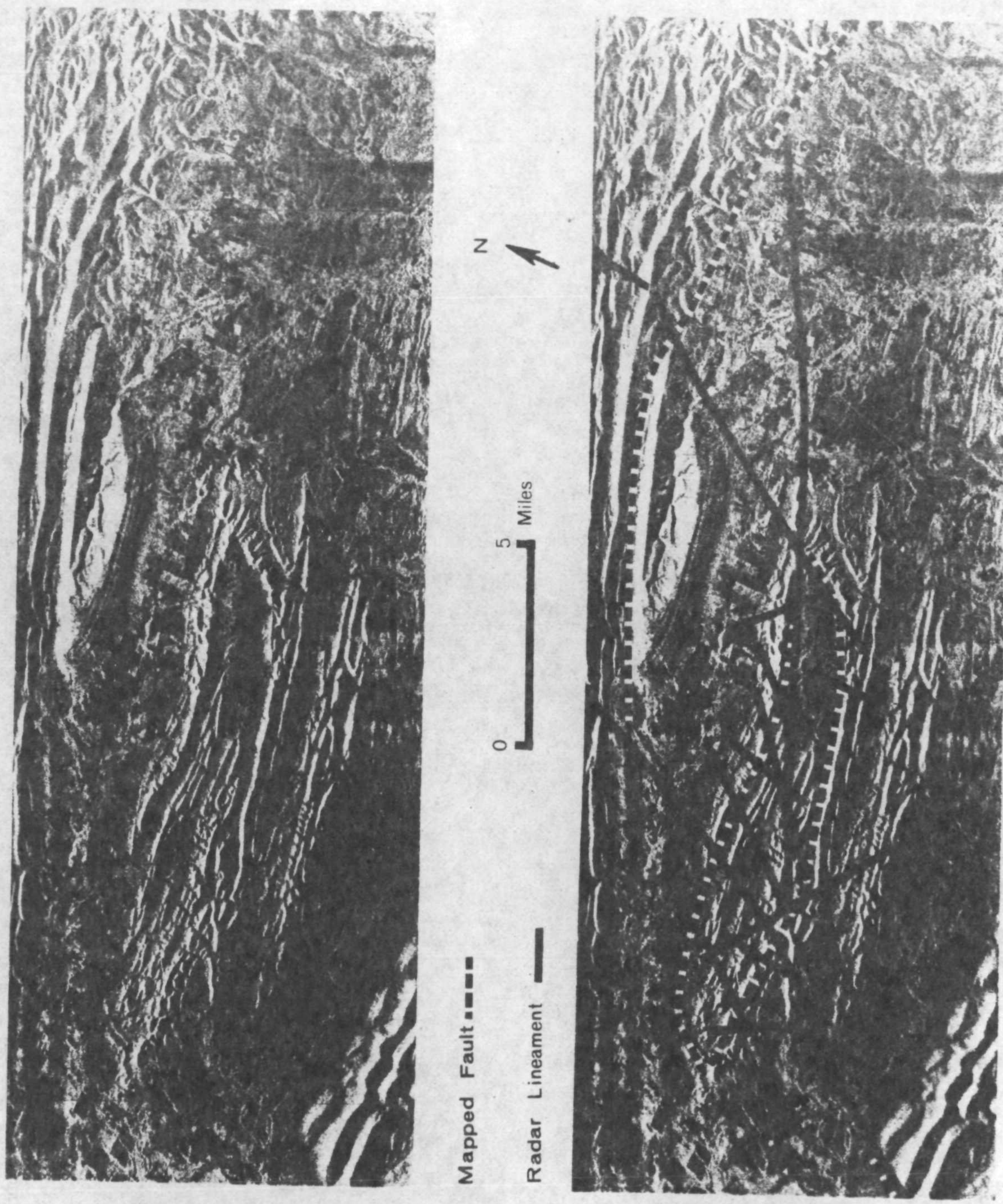

Figure 1. Geologic interpretation. Radar imagery and interpretation of the Potatoe Hills, Oklahoma, showing lineaments cutting across boundary faults as located by Miser. (Dwellig)

(2) The acquisition of soil data is another area where remote sensing has demonstrated its utility. However, the status of soil information in the Washington area is much the same as that of geology. The soils of the metropolitan area were mapped in 1967, and because of the nature of this resource, and the relatively little likelihood of rapid change by natural causes, there is little reason for up-dating. Prime lands for development purposes are generally closely equatable to land which has had a useful agricultural history, by virtue of its rich soil characteristics. For many reasons, communities may desire to retain such land in a non-developed status or to control its transfer to more intensive usage. Remote sensor surveys are useful in this respect to support specific planning programs or to accomplish basic soil mapping of the area where needed. See Figure 2.

(3) Slope mapping is also an application where remote sensing can be used for gathering the necessary data. From stereoscopic coverage and analysis of an area under examination, maps can readily be developed to identify and characterize the existing slopes in that area. The method currently used by the Council of Governments' analysts is to develop contour information from existing U.S. Geological Survey topographic map sheets of the metropolitan area. (Natural Features, p. 48).[14] The major problem, of course, is the age of the available maps. Up-dating occurs usually at least every five years. Of course, basic topographic features of the area, unless changed by

A—Clays of the Brandon series. The better drained ridges can be distinguished and the sands around the bedrock outcrop can be clearly delineated.

B—Brandon clays, organic soils and Brebeuf Loams, both silty and sandy.

C—Fine loamy sands of the Ivry series. The speckled appearance results from partial removal of the top soil by wind erosion.

D—Sandy loams of the St. Gabriel and Lesage series. The latter exhibits phase differences due to variations in parent material, moisture and organic content.

E—St. Gabriel sandy loams. The mottling results from differences in texture and moisture content. The micro-relief features are abandoned meltwater channels.

F—Brandon clay with patches of sandy material on which sandy loams of the Piedmont series have developed.

Figure 2. Soils identification using color photography. Lac Bevin Basin, Canada. (Parry)

man or nature, should not be materially altered during this interval. However, changes wrought by urbanization frequently alter the contours of the land, causing some of the data to be out of date even as it is gathered. Since topographic maps are themselves based on data from aerial photography, remote sensing can just as readily provide current data on this aspect of the natural environment, and thereby provide a relatively more rapid means of maintaining up to date information in areas where needed.

(4) Two additional aspects of the natural environment that might benefit from the use of remote sensing are determination of soil moisture and presence of natural resource deposits. Knowledge of soil moisture is necessary for flood prediction, as a guide in land use plans and as an engineering factor required for construction planning. Anderson and Keifer have both indicated that remote sensing can readily be used for the identification of areas of excessive soil moisture. (Anderson, p. 26-28)[2], (Keifer, p. 49-70).[7] Data derived from conventional imagery can also be used for inventorying important resource extraction activities such as sand and gravel deposits in an area. (See Figure 3). Similarly, assessments may be made of the encroachments upon these and similar resource activities by expanding urbanization. Data on natural resources as yet undeveloped would undoubtedly be well received and should certainly be noted in planning studies as areas to be reserved for special development. Use of specialized airborne geophysical

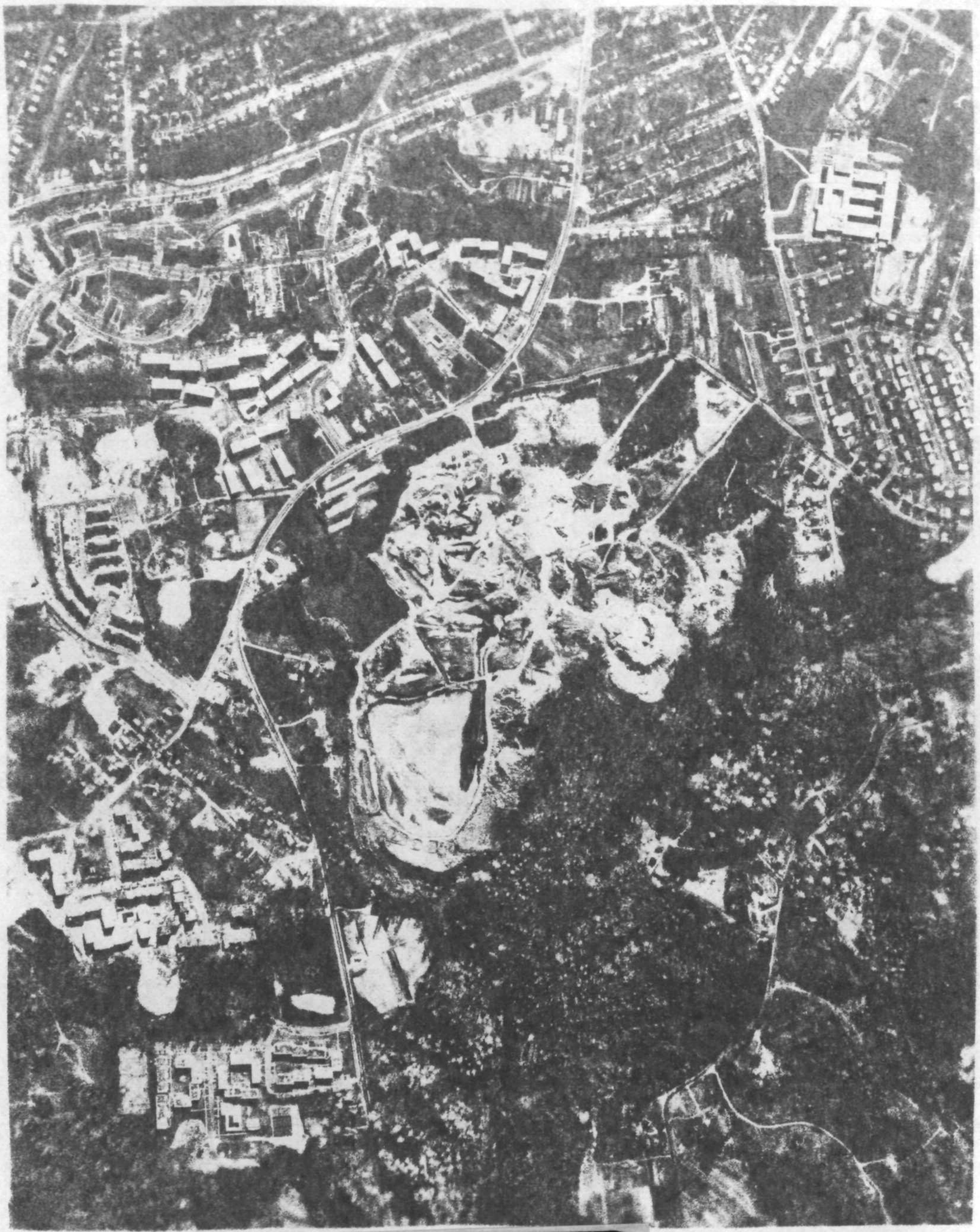

Figure 3. Sand and gravel operations. Metropolitan Washington area. (Air Photographic, Inc.)

instruments (magnetometers, gravity meters, etc.) in addition to imaging systems are useful tools when used in conjunction in this exploratory application.

B. Transportation

In the provision of transportation data, remote sensing has already demonstrated many practical uses. The transportation planner's data needs include information on traffic volume, traffic speed and delay movement, vehicle types and mix, routing of vehicles, turning patterns, parking and terminal facilities and trip generation. Remote sensing can contribute in some respect to all of these.

Traffic volume, for instance, can be easily measured by photographing routes under study during rush hours or other periods and by counting cars within assessment points in the stream. In addition, traffic speed and delay patterns can be monitored simultaneously by the use of time-lapse helicopter photography, as demonstrated by Project Skycount. (Caggiano, p. 15).[4] As Caggiano has noted, "No longer is it necessary to base all research data on vehicles passing a point on a roadway or through a short-based electrical or electronic trap." (Caggiano, p. 11)[4] Traffic patterns can be studied fairly rapidly and with ease from airborne platforms. Analysis of traffic flow patterns could also be coupled with postcard or other survey techniques to sample vehicle routing during trips. Figures 4 and 5 are examples of time-lapse photographs which could be used to study traffic routing, speed and delay patterns, and volume.

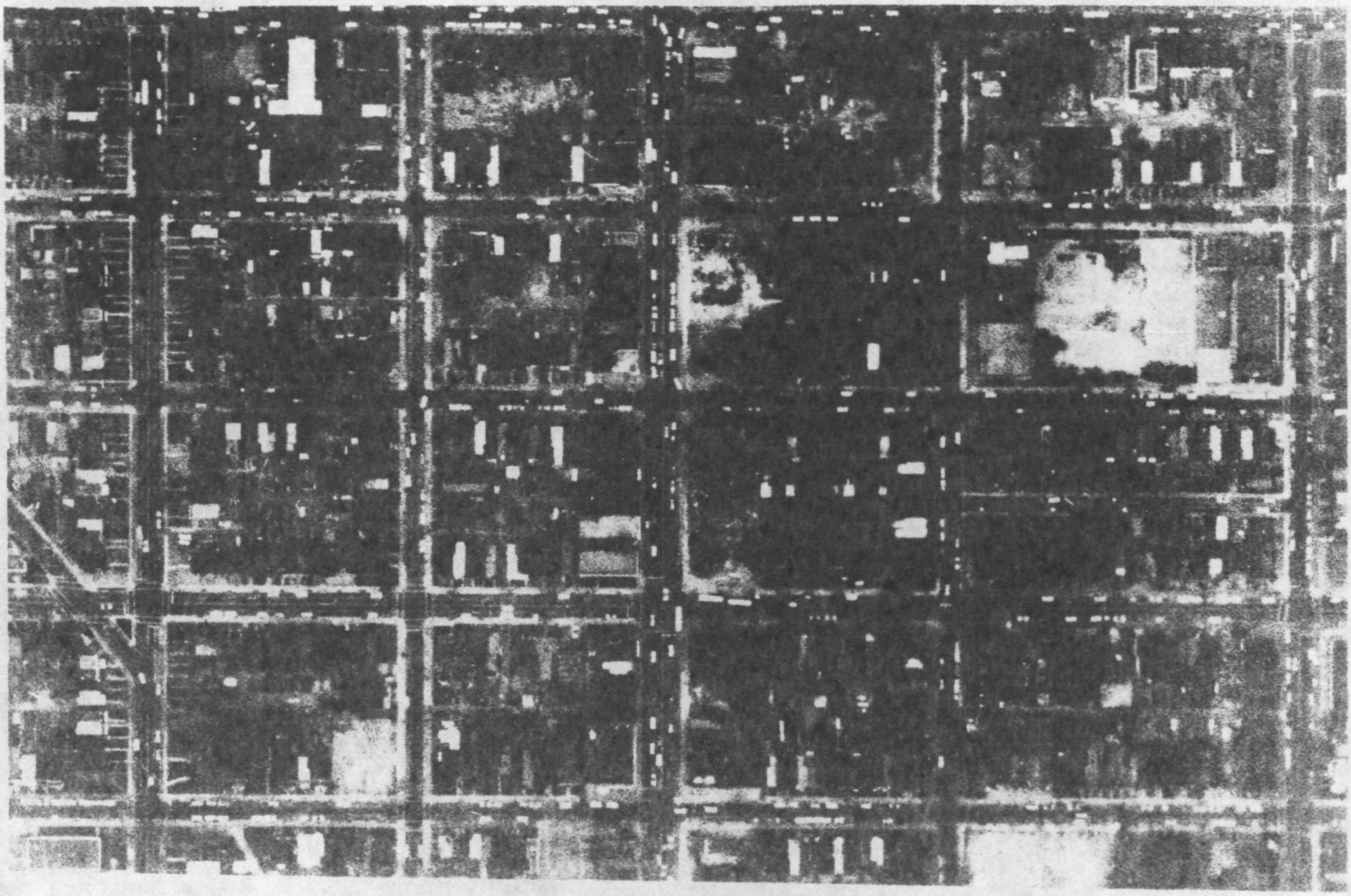

Figure 4. Time-lapse photography for use in traffic movement studies. Note difference of positions of cars between Figure 4 and Figure 5. (USGS Photo)

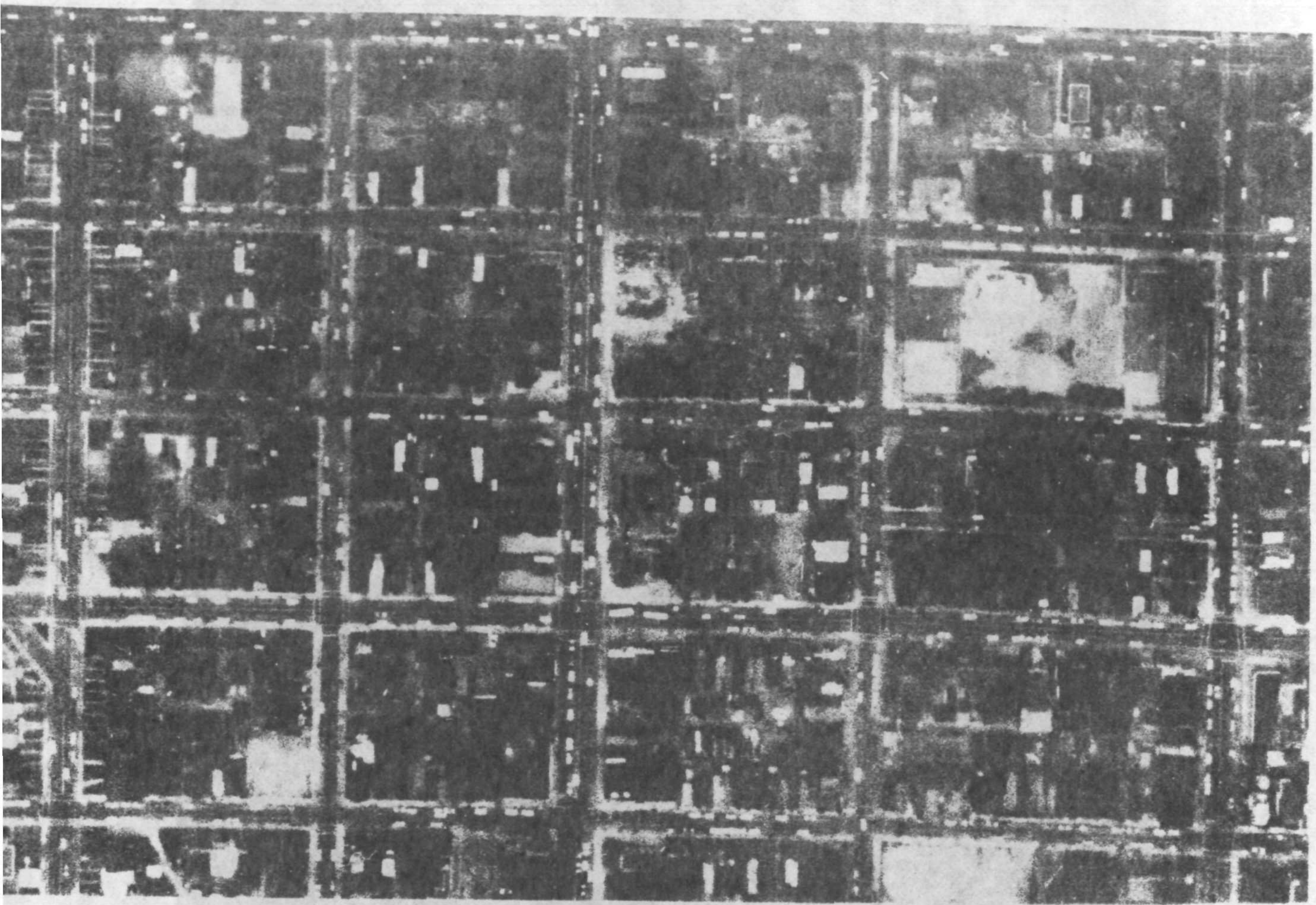

Figure 5. Time-lapse photography for use in traffic movement studies. (USGS photo).

The use of photography for the study of parking and terminal facilities and capacities has the advantage of permitting an effective use of a total system area approach. With appropriate coverage of the area and selected imagery scale, an entire terminal highway system can be analyzed simultaneously to provide data on traffic behavior, available parking facilities, density maps by time of day, and so on. (Caggiano, p. 11)[4]. Figure 6 presents an example of such an overview over Washington National Airport.

Remote sensing has the unique characteristic of providing a synoptic and instantaneous overview of transportation networks for graphic presentations, (See Figure 7), or for general planning uses, (See Figure 8). Other specific uses, depending on the photo scale employed, include determining the alignment of highway, pipeline routes, etc. (See Figure 9). Furthermore, sequential or repetitive photography at differing periods has, as has been mentioned, almost unlimited application for studying time-variant traffic behavior.

C. Land Use

There is one area of urban data that is an input to almost every COG program, either directly or indirectly, i.e., land use. It indicates how land is being used, the amount of land in various categories of usage and the patterns and trends of land use development. Land use data ia a basic input to COG's Empiric Activity Allocation Model, which provides forecasts of future regional population and employment, COG's Storm Runoff

Figure 6. Washington National Airport overview. Black and white print of color infrared imagery. 1:50,000. (USGS/NASA photo)

Figure 7. Highway interchange. Capital Beltway and Interstate Route 70S. (Air Photographics, Inc.).

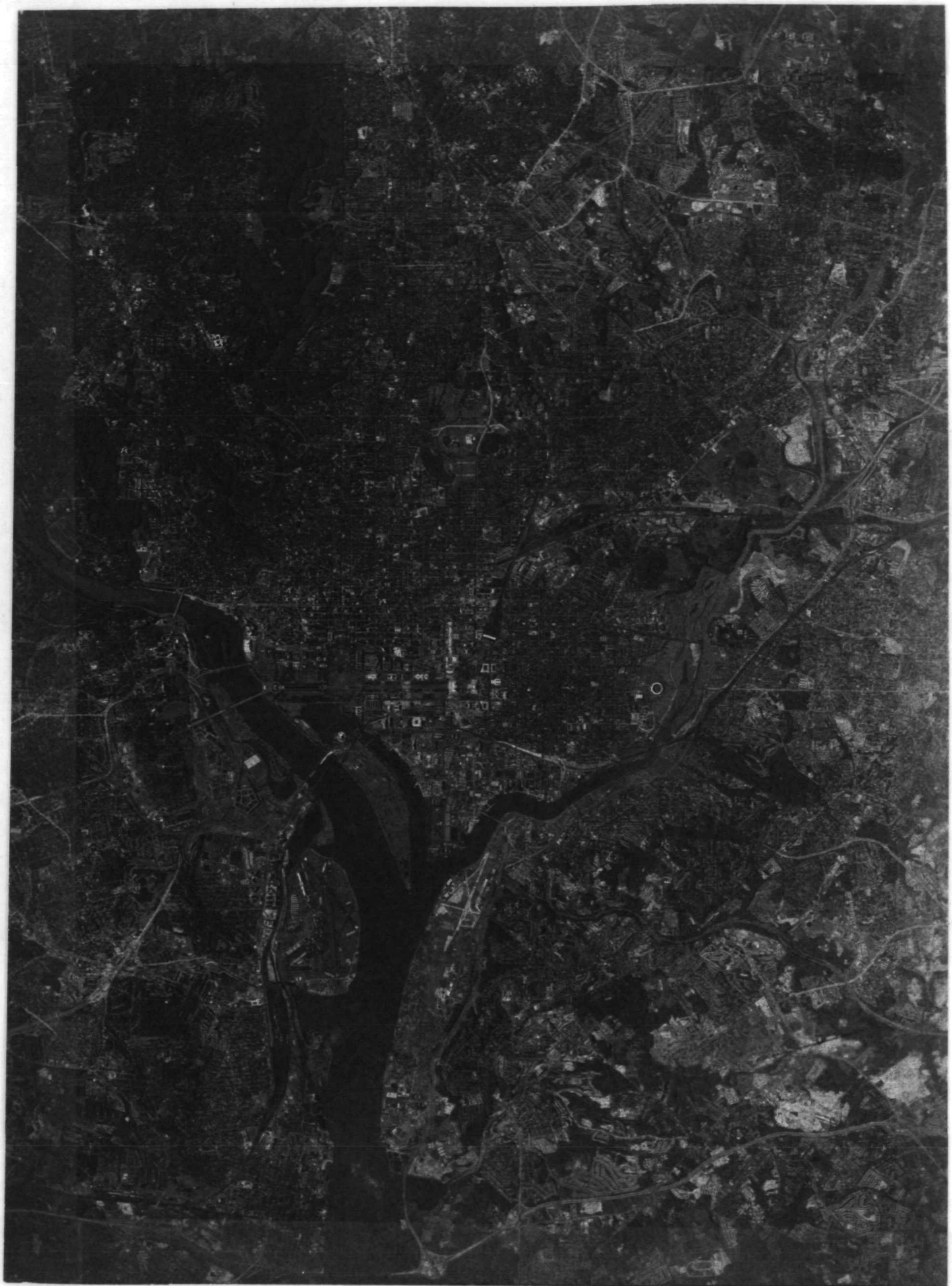

Figure 8. Overview of Washington, D.C. transportation network. Black and white print of color infrared imagery. 1:100,000 (NASA photo)

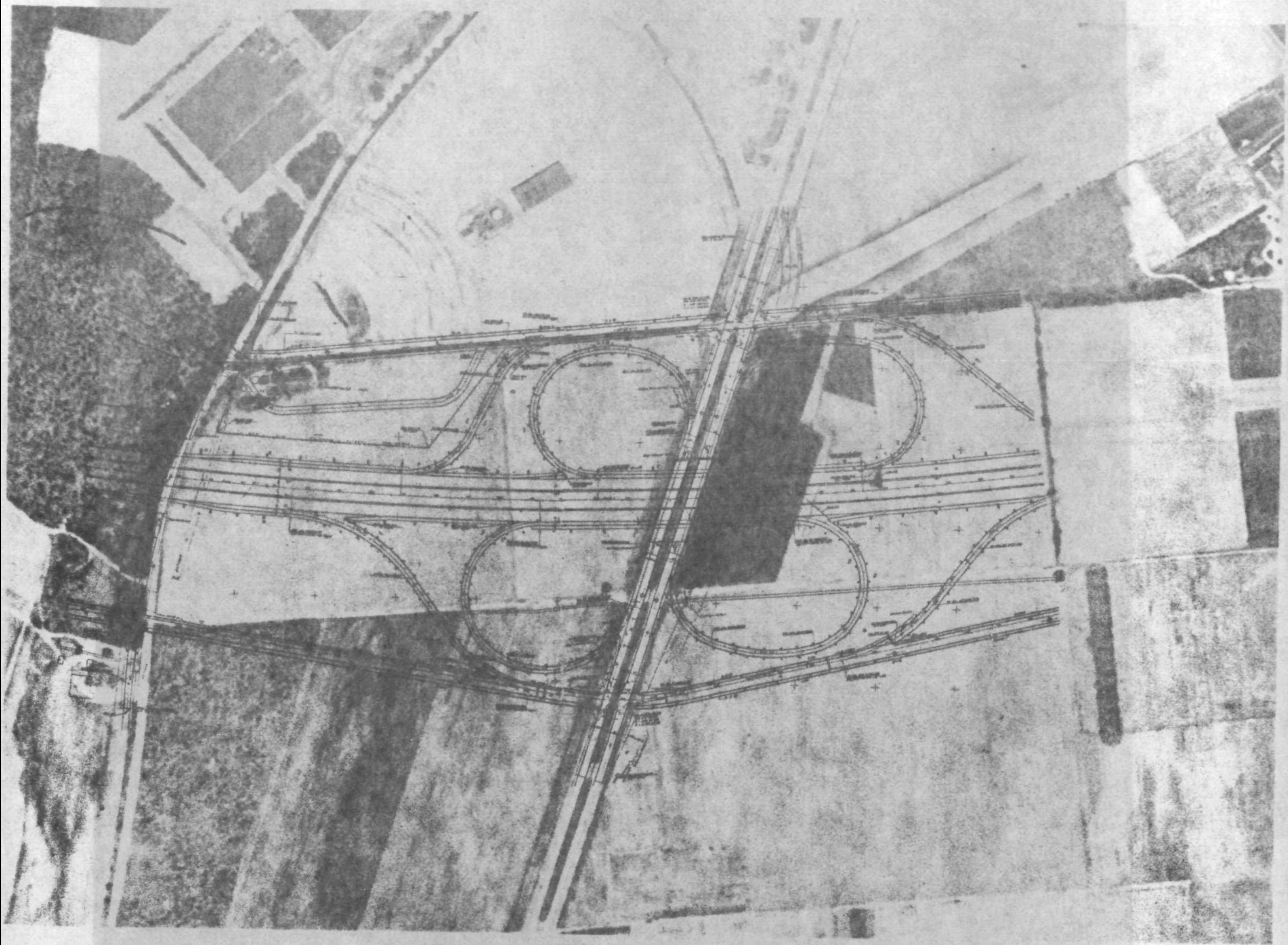

Figure 9. Example of highway planning using aerial photography. (Lockwood, Kessler & Bartlett, Inc.)

Model and other predictive analyses. The data ia also used in transportation studies, checks of land compatibility, and in the Council of Governments' Changing Region and State of the Region reports as well. It is basic to the monitoring of areas of special interest such as open space, wetlands, flood plains, and areas of services adequacy, (utilities, for example).

The Metropolitan Washington Council of Governments maintains a parcel file which, among other items, contains data on land use within the region. A study of the contribution that remote sensing can make to acquiring land use data was recently completed as a part of this project. (Mallon and Howard).[9] That study concluded that a primary contribution of remote sensing data in the Washington area would be to improve the regional land use data in the existing parcel file. Since that file is the source of basic data for a great many Council of Governments' programs, improving its accuracy is to be encouraged whenever a means presents itself. Currently, the parcel file has a great deal of land which it cannot assign to a specific location, while on the other hand, it does not include some land of importance. Through a correlation of imagery-derived land use data with data from the parcel file, much acreage currently unassigned can generally be located, and omissions corrected. Pipelines and powerline rights-of-way, for example, are frequently omitted from land use base data. (See Figure 10).

The value of remote sensing data to the development of a metropolitan land use inventory appears to be inversely

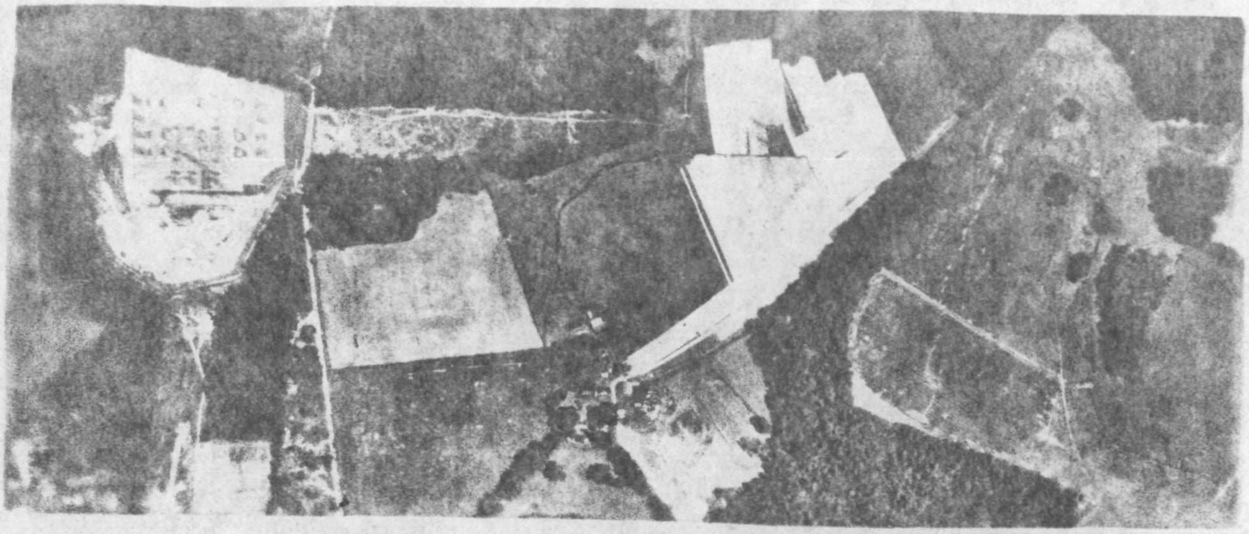

Figure 10. Power lines and junction point.
(Air Photographics, Inc.).

proportional to the state of development of the metropolitan data file. Where no metropolitan data file exists, remote sensing analysis can provide uniform land use data detailed to at least the two digit level (as defined by the Council of Governments' General Land Use Category Code).[9] In areas where a metropolitan data base is under development, or already in use, remote sensing provides the means for checking the existing data, improving it, and enlarging it (to reflect change and growth) rather than a means of developing the data base itself.

Apart from improving the Council of Governments' parcel file, there are two other aspects of land use which would merit the use of remote sensors. One would be the updating of the Council of Governments' regional base mapping and overlay series. "At the present time, the updating of this series is costly and time-consuming. Information is rapidly becoming outdated... and the series is losing its immediate utility to decision makers". (MWCOG proposal).[12] The use of remote sensing for inventorying some of the information contained in the series would permit the Council of Governments to maintain the series more efficiently. It is probably also the best means of updating the metropolitan land use map which appears in the Council of Government's Changing Region report and for providing a visual expression of change in the Washington metropolitan area.

Another aspect of land use delineation to which remote sensing data are applicable, is the detection and monitoring of change due to growth or other influences in the metropolitan area. (Howard).[8] Of particulary interest is the monitoring of change in order to predict change. Urban changes assume special importance to the urban planning process when they occur on planned open space, flood plains, wetlands, areas subject to environmental degradation from noise, water and air pollution, and areas of inadequate services. Identification of areas such as these, which require control of development, is already underway at Council of Governments. "Maintaining an inventory of such areas and the rate at which development is occuring constitutes a major effort at Council of Governments." (MWCOG proposal).[12]

The contribution of remote sensing to monitoring change of such areas is appreciable. Regular and periodic photographic coverage of the region would be a means of monitoring encroachment on the areas of special interest so that appropriate action can be taken to prevent damage and misuse of the land. Its use as a "remote enforcer" of land use policy is only beginning to be realized.

D. Housing Quality

Quality of housing stock and neighborhood condition in the metropolitan Washington region represents a high priority area of information need and planning concern to the Council of Governments. Information on the number and types of dwelling units, their location, age, condition (deterioration or abandonment in urban centers), essential services, and status of neighborhood facilities are among principal indicators which are assessed to provide estimates of the general character and condition of housing in the area. (Mallon and Howard)[10].

These essential variables are not always observable in remote sensor imagery. Therefore, it is necessary to look for substitutes or "surrogate" indicators of structural or environmental yardsticks visible in the imagery. These include building density, litter and trash accumulation, parking (on or off-street), curbings, presence of and extent of vegetation, street width, building access, empty lots between buildings, general areal appearance, presence of mixed residential (commercial or industrial) areas, and so forth.

Analysis of these variables on fairly large scale imagery, along with a familiarity of the area under examination, is an application permitting fairly accurate assessment of the conditions sought. (See Figures 11 and 12). For general survey and for delineation of selected areas for detailed examination by ground survey or other methods, smaller scale imagery is more useful. (See Figure 13).

E. Flood Damage Prevention

Flood damage is a recurring and pressing metropolitan problem and rapid urbanization in previously virgin watersheds increases the flood damage potential. (MWCOG proposal)[12]. Basic

Figure 11. Single-family residence viewed at very large scale imagery, (approximately 1:500). Note chidrens' swings and clothes line. (USAF photo).

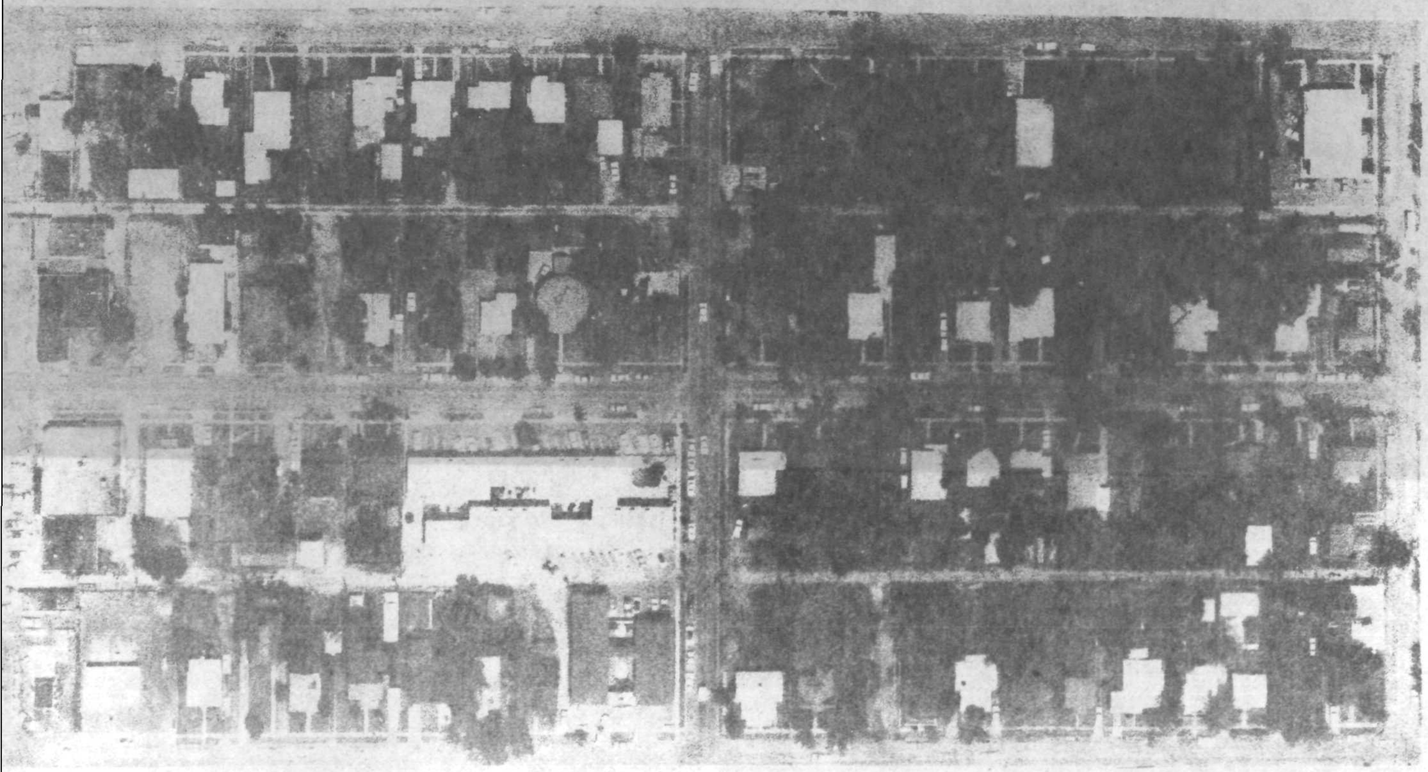

Figure 12. Urban residential area viewed at a scale of approximately 1:2200. Note motels and number of occupied accomodations. (NASA photo).

Figure 13. Central, Anacostia, and SE residential areas of Washington, D.C. viewed on 1: 50,000 scale imagery. Note expanding development in SE areas. (USGS/NASA photo)

to the structuring of flood damage prevention and control plans is an understanding of the complex meteorologic, hydrologic and hydraulic characteristics of the region. (MWCOG proposal).[12] As part of a Council of Governments' Urban Water Resources Planning Project, the Council of Governments is developing a storm drainage system model of the Washington region. (MWCOG proposal).[12] Flood damage prevention information is required on the extent of flooding and the configuration of the flood plain under various conditions. (MWCOG proposal).[12] It also requires timely information on urban growth patterns and on flood-related parameters such as imperviousness of various surface areas within the region.

Flood data is presently being obtained by each of the local jurisdictions through cooperative efforts with Federal agencies or private consulting engineers. The U.S. Army Corps of Engineers conduct, upon request of local agencies, flood plain investigations. Their reports include maps, profiles, charts, graphs, tabulations and narrative descrip-ionstof flood damage for the drainage basin studied. Unfortunately, these studies can only be performed as man-power and funding permit. To date, only six drainage basins in Maryland have been studied by the Corps of Engineers and, as of February 1970, only four other studies had been given a scheduled starting date. (Flood Damage Prevention Activities, p. 20).[6]

Within one to two years, the U.S. Geological Survey should have finished a complete set of flood plain maps for all Fairfax

County, Virginia streams, upstream to the point at which the stream drains only one square mile of land (Flood Damage Prevention Activities, p. 18).[6] Figure 14 indicates the status of drainage basin studies in the metropolitan Washington region as of 1969.

Although engineering studies such as these are the preferred source of flood plain data they are still unavailable for a great many areas within the metropolitan region, as Figure 14 illustrates. In their absence, it has been necessary to rely on soil data maps as substitute data sources. (Natural Features, p. 30).[14] Remote sensing analysis can provide data on the topography of a flood plain in basically the same manner that it is used as the primary source of data for topographic maps. As Firmin has noted, it is possible to delineate the limits of a flood plain on aerial photography from which flood elevations can be determined (Firmin, p. 129).[5] Through photogrammetric analyses of steroscopic coverage, contours can be delineated and, from them, the limits of a flood plain. Remote sensing is also able to monitor changes in the various flood plains resulting from increased urbanization.

Another important input to the Council of Governments' Storm Drainage System Model; namely, percent of impervious land, can be easily and rapidly identified with the use of remote sensing techniques (See Figure 15) and measured by specialized viewing equipment. The acquisition of these data by field work would be a costly and time consuming project. By utilization

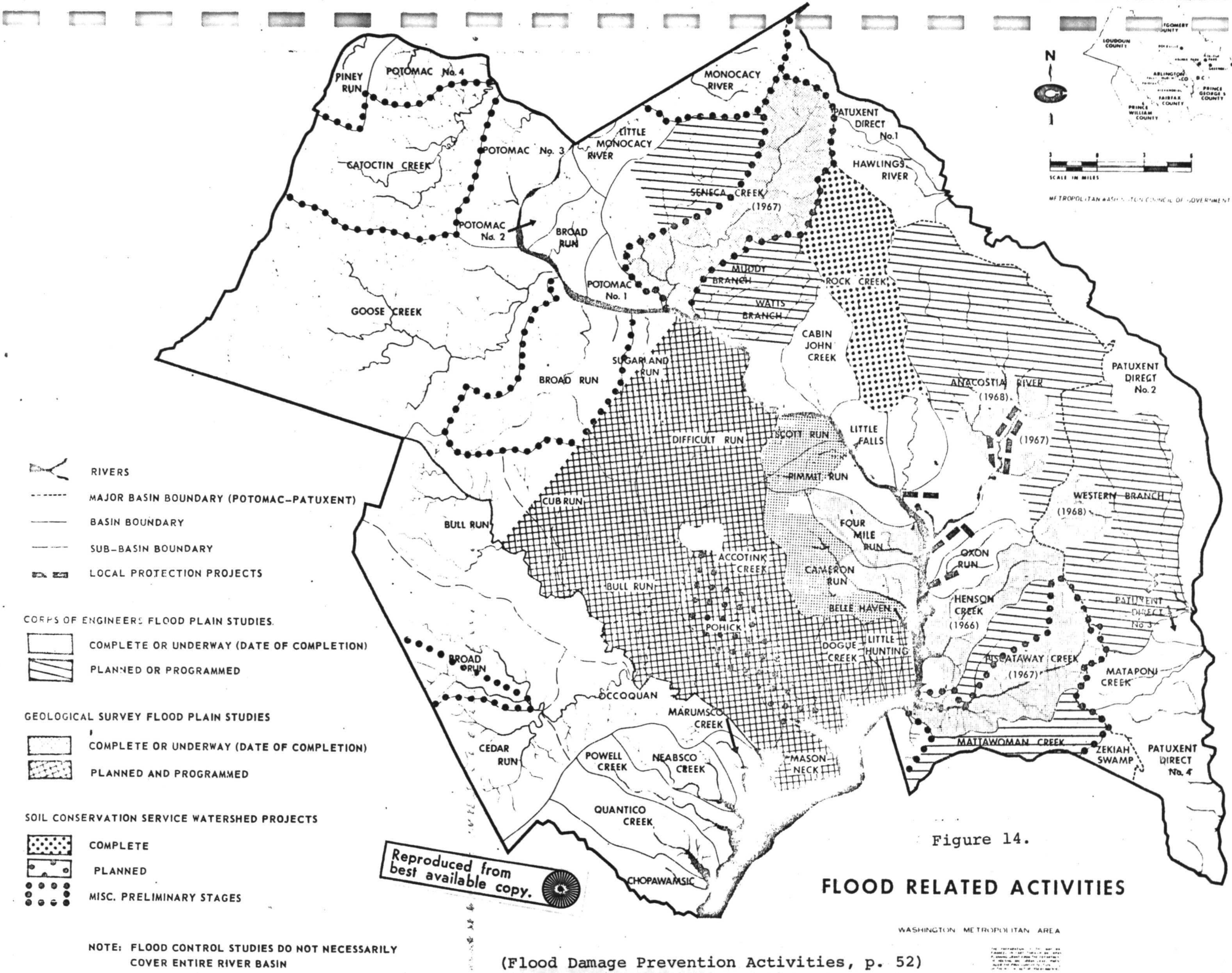

Figure 14.

(Flood Damage Prevention Activities, p. 52)

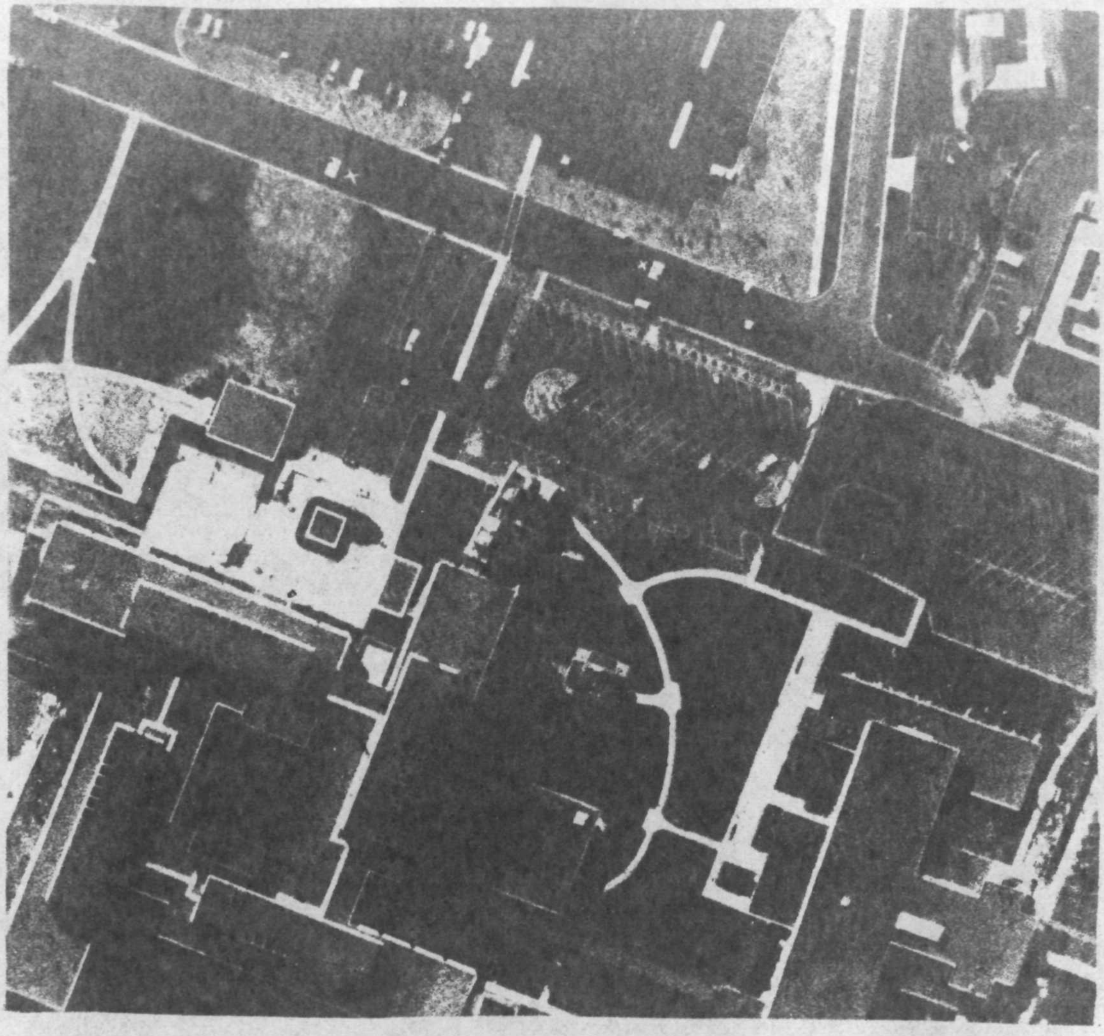

Figure 15. Urban impervious surface areas. (NASA photo).

of vidicon image digitizing devices, for example, photo imagery derivatives, (tracings of impervious surfaces within areas being investigated), may be rapidly analyzed and the required percentage data developed. A successful test of this technique was undertaken at the U.S.G.S. Silver Spring, Maryland Office.

Data from remote sensing could be combined with other data from conventional sources to develop a flood potential warning system. Precipitation and temperature data could be combined with snow cover data from remote sensors to provide an index of snow melt runoff. Channel characteristics, which change due to sedimentation or attrition could also be monitored by remote sensors providing an up-to-date knowledge of channel volume capabilities. In addition, basin hydrologic data, such as estimates of surface water storage and patterns of deficit or surplus soil moisture can also be provided by remote sensors as inputs to a flood potential warning system. Extent of surface water can easily be measured on various types of imagery. Figure 16 demonstrates in particular the use of SLAR imagery for detecting and inventorying surface water areas. A good overall look at basin characteristics can also be achieved with the use of SLAR imagery. (See Figure 17).

Remote sensing can also use its monitoring capabilities for data acquisition in support of enforcing certain runoff retention regulations. Montgomery County, Maryland, currently has a regulation requiring builders to restrict the amount of storm runoff from their property to the amount that existed

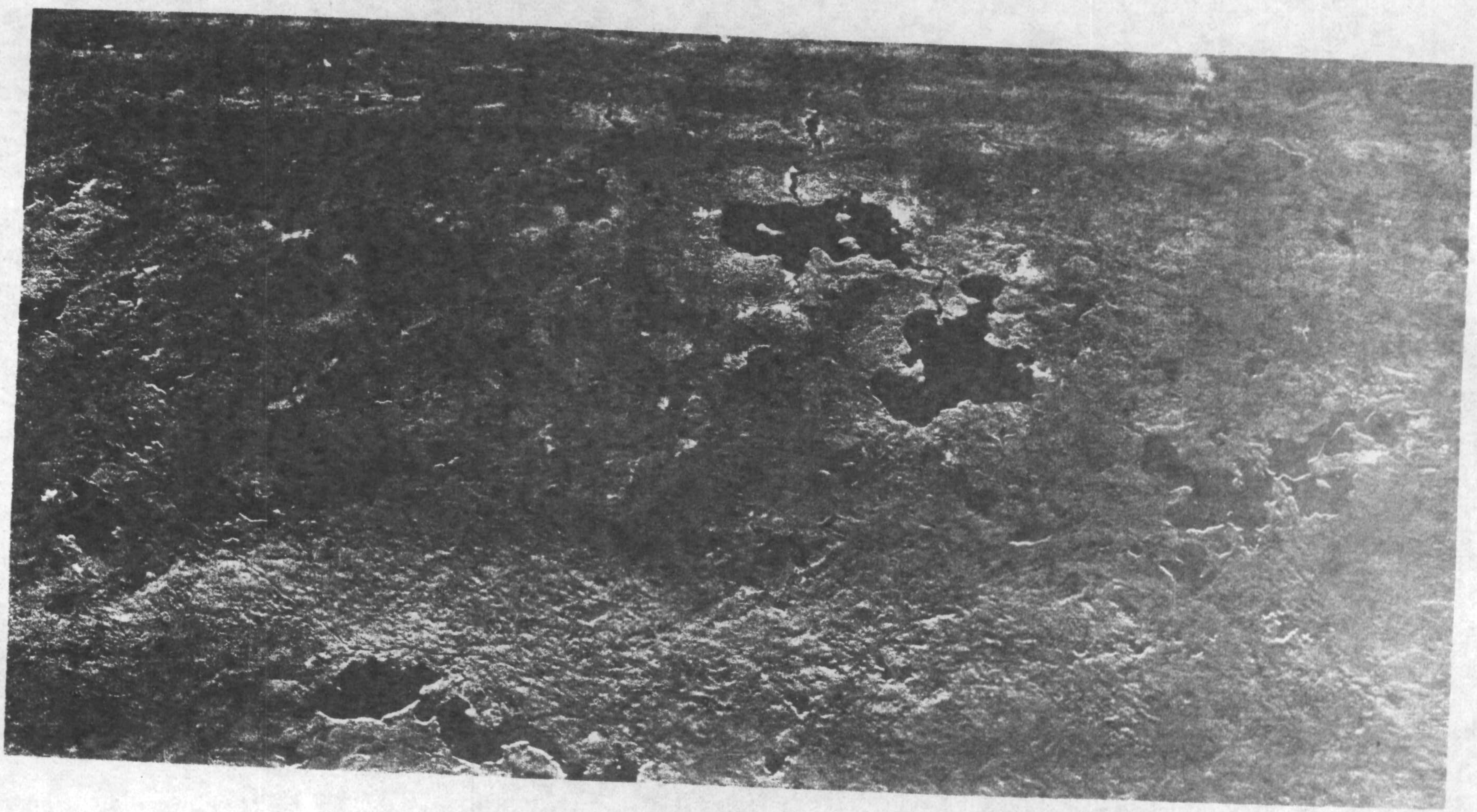

Figure 16. Surface water images black on SLAR imagery. (Westinghouse imagery)

Gogebic Range Area, Michigan

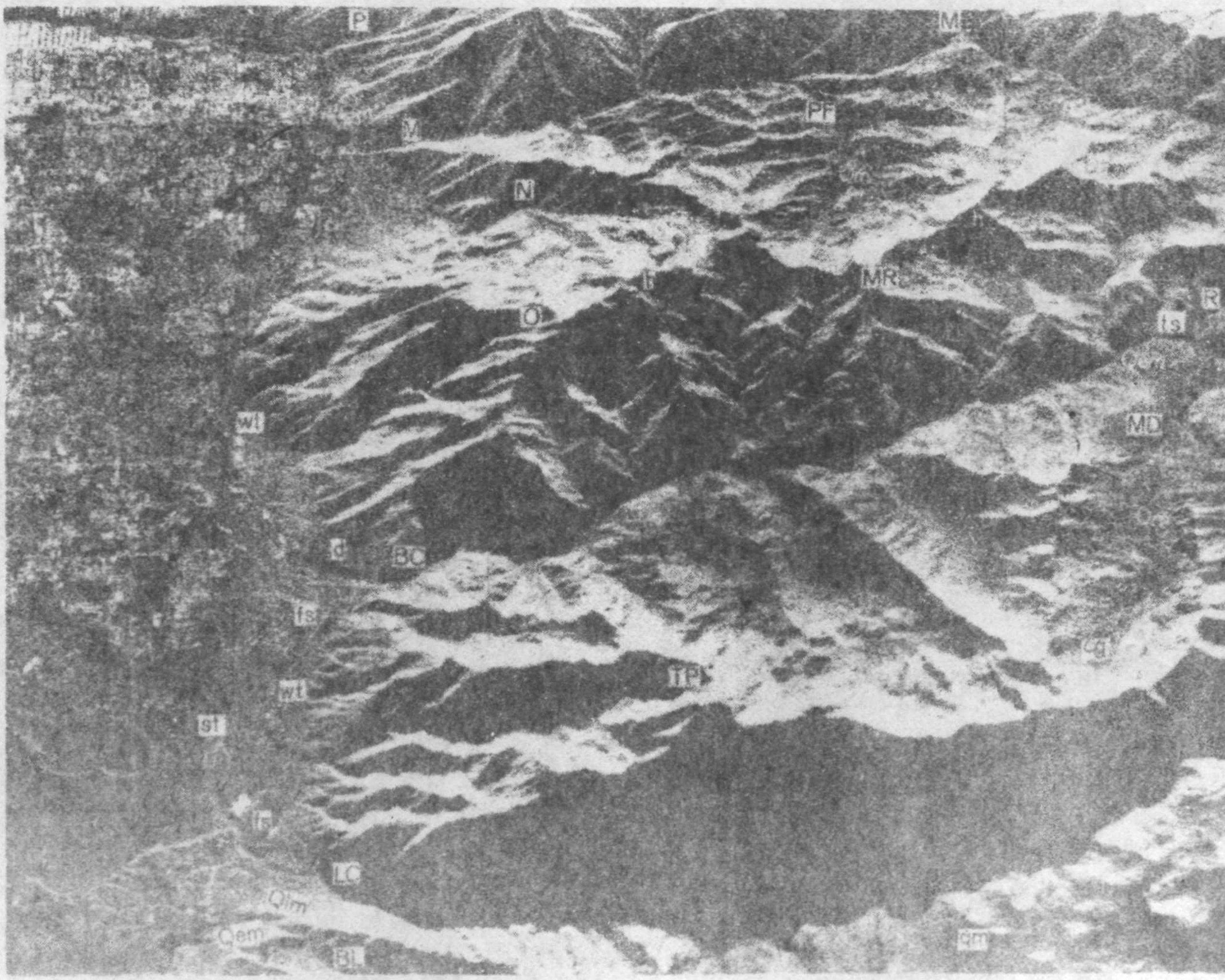

Figure 17. SLAR overview of western eight miles of Wasstch Range and part of Salt Lake City. Note ease of drainage basin delineation. (Peterson)

before the land was developed. In order to do this, ponding on building roofs and on the land, capable of retaining up to six inches of rainfall, has been instituted. In order to ensure that the practice of ponding continues once construction has been completed, remote sensors could periodically monitor areas within the county after rainstorms. Offences could then be noted and appropriate correction actions initiated.

F. Sedimentation

Another program in which Council of Governments has become deeply involved is the institution of erosion and sediment controls in the Washington metropolitan area. "Erosion and sediment control activities require an understanding of the complex mechanisms of soil detachment, transport, and deposition in order that cost-effective solutions can be developed. Knowledge of these mechanisms, though increasing daily, is not sufficient, particularly in the urban areas of the country, to have generated public demand for erosion control measures... sufficient to improve the water pollution and sedimentation problems. The use of remote sensors promises to be of value in increasing an understanding of the erosion/pollution/sedimentation problem." (MWCOG proposal).[12]

In particular, there are three aspects of sedimentation for which remote sensing under certain conditions can provide

Figure 18. Erosion patterns in partially developed areas. (Air Photographics, Inc.)

data; (1) sources of sediment (See Figure 18), (2) sediment transport, (3) sediment deposition patterns.

In determining sources of sediment, color infrared imagery is a useful tool for identifying and mapping areas of exposed soils, since exposed soils generally image white. See Figure 19. Repetitive coverage of the region could then be used to estimate the rate at which new areas are being exposed and older areas being covered, and also to locate areas which have been left exposed for periods longer than permitted by state and local laws and regulations. It cannot always be used to pinpoint a specific sediment deposit created by any one offender. However, remote sensing data provides excellent tools for monitoring areas which have been left exposed for excessive periods of time and for observing sedimentation accumulations. Such information made available to local agencies and researchers would assist in developing the basis for evaluation of alternative erosion control techniques and to alert local officials to the need for modification of local regulations for building and grading operations. (MWCOG proposal).[12]

For the study of sediment transportation mechanisms, color and color infrared imagery can provide a valuable tool for the detection and delineation of sediment. The particulate matter in suspension being carried in the water affects the color infrared emulsion so as to produce lighter image tones for water containing the sediment as compared to water with relatively less of a sediment burden. Imagery can be used to discern patterns of sedimentation prevailing in selected water-

Figure 19. Exposed soils can be monitored with infrared imagery (generally the white or light areas). Black and white print of color infrared imagery Alexandria-Fairfax County, Virginia. 1:50,000. (USGS/NASA photo)

ways under various conditions as well as to locate sediment discharges into waterways. (See Figures 20 and 21). It can also be used to trace the movement of water in waterways to gain a better understanding of pollution transportation mechanisms. (See Figure 22). When coupled with simultaneous ground level tests, the sedimentation patterns observed in the imagery could be used to calibrate mathematical models for possible expression of the movement of sediment and other particulate substances.

Sedimentation as a part of natural erosional processes is generally irreversible, and unless controlled, can create serious environmental problems. The study of these problems requires timely data on the location and movement of sediment deposition. Remote sensing data has present applicability as a monitoring, and generally, as a qualitative information source. Much research work remains to be done, however, to determine quantitative relationships between sediment sources and related transport mechanisms and specifically how these phenomena may be determined by remote sensing analysis.

G. <u>Pollution</u>

Preservation of ecology and control of pollution are now major goals accepted by a large sector of American society, and the Council of Governments is one of the many organizations and agencies engaged in working towards these goals. The relative newness of the field, however, has resulted in a lag in the coordinated development of the means of monitorship and control of polluting activities. Remote sensing can currently be of use in gathering data on many aspects of pollution, but its

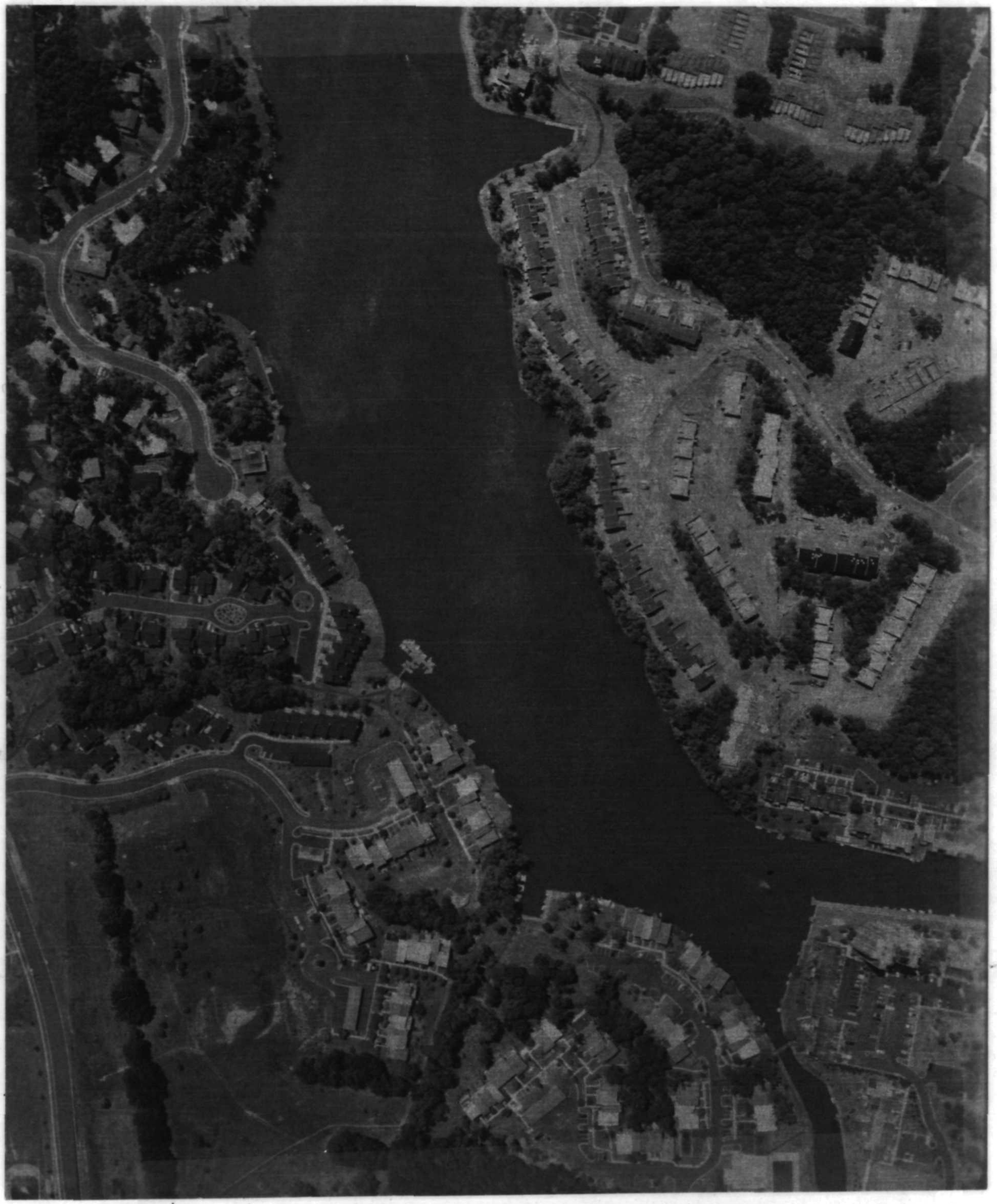

Figure 20. Runoff into lake from cleared area. (Photo Science, Inc.)

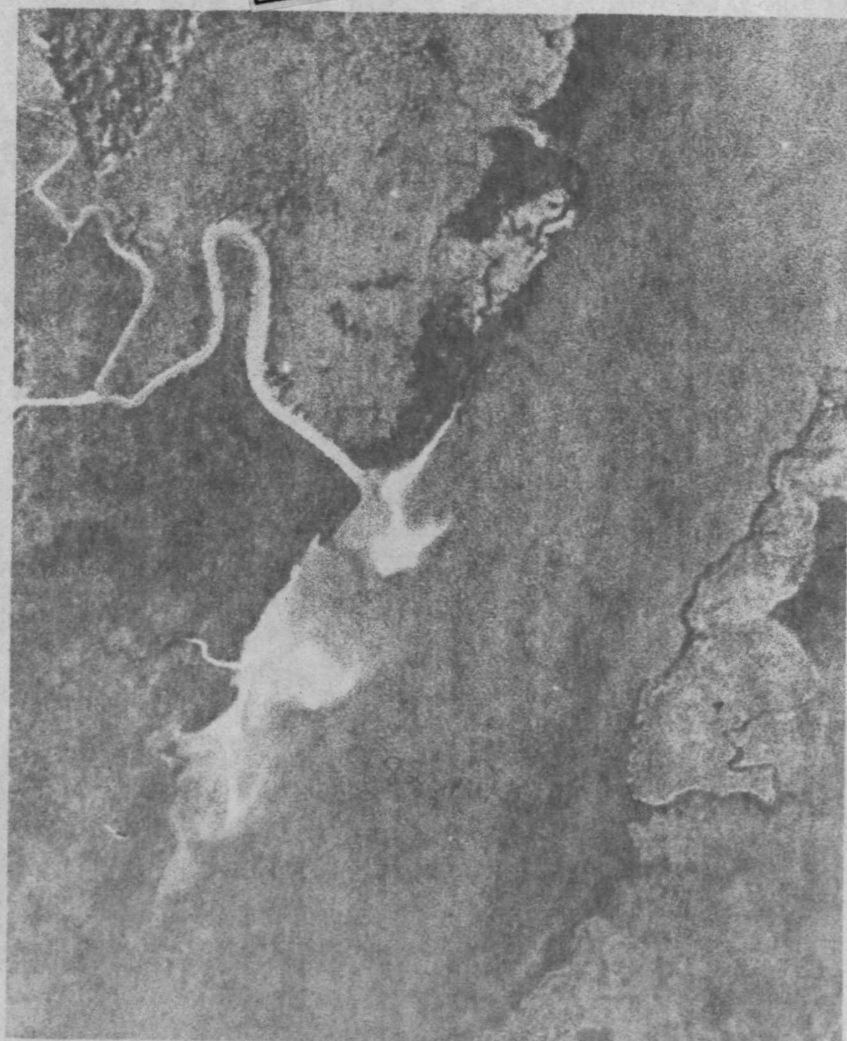

Figure 21. Signature characteristics of silt-laden water and pattern of dispersion in the Patuxent River estuary. 1:12,000 (Anderson)

These Photographs are Black and White
Reproductions of Agfachrome Color Slides.

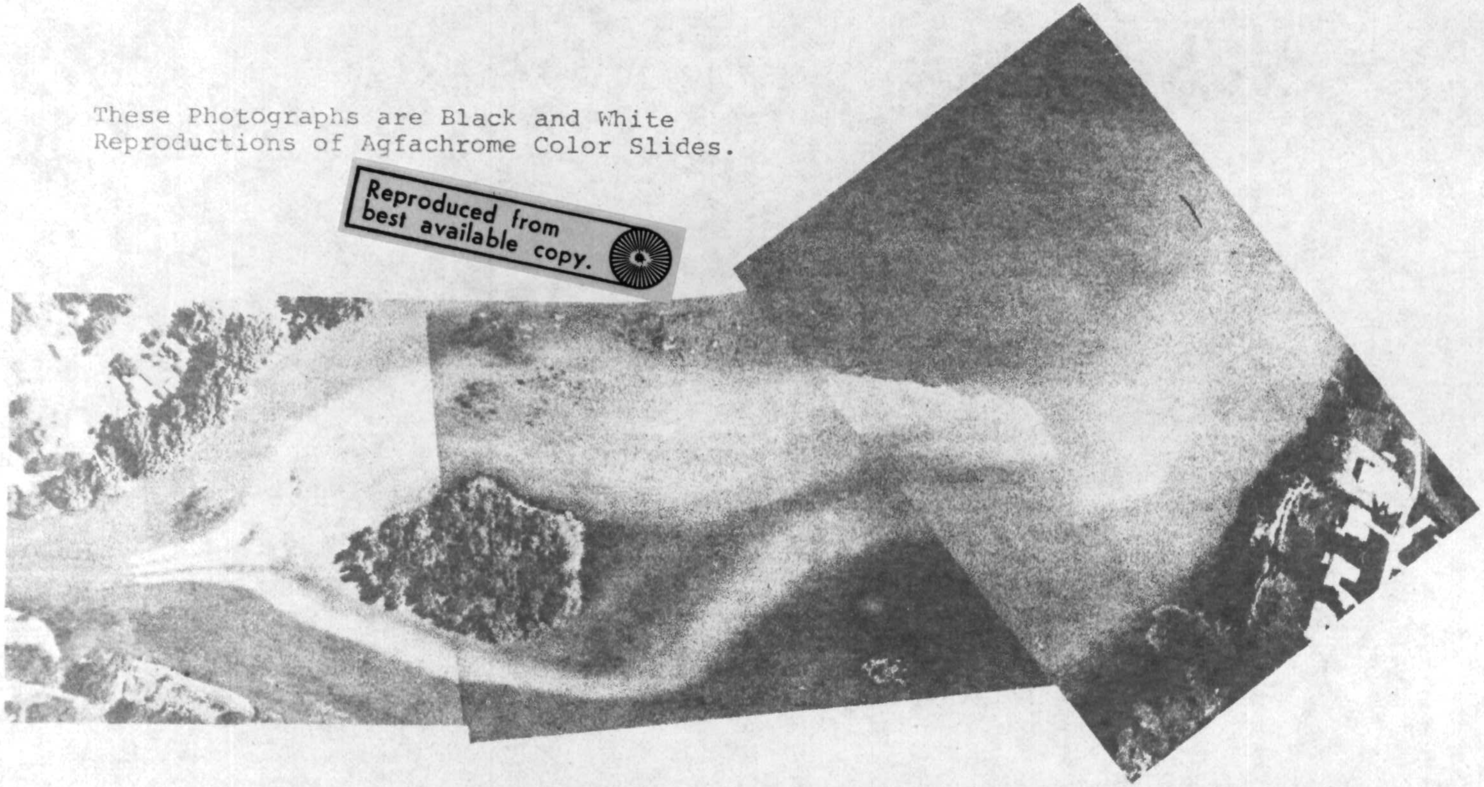

Figure 22. Water transport mechanisms and patterns. Photographs of Fox River near Appleton, Wisconsin, illustrating low aerial images give an overall view of flow and mixing patterns which were not discernible to men in boats or on shore. (Scherz)

full potential as a monitoring tool (in particular for air pollution) has yet to be realized.

At the present time, remote sensing can be easily used to monitor areas contributing to sedimentation because of foreign matter in the water, as was discussed above. It can also be used to detect a wide variety of ordinary and sometimes surrepticious discharges of pollutants into the water, although it cannot always identify the separate chemical constituents of these discharges. Among the pollutants that remote sensing is capable of detecting are sewage and other oxygen demanding wastes, organic industrial wastes, and oil spills. (See Figures 23, 24, and 25). Thermal imagery is also particularly useful for investigating heat pollution of streams. (See Figure 26). By inference or indirect means, plant nutrients, irrigation return flows, and agricultural pesticides can also be detected. For example, excessive algae growth, clearly visible in color infrared imagery would indicate pollution by nutrients somewhere upstream. (See Figure 27). Fish kills in turn could indicate pollution from chemical plant wastes, pesticides or because of reduction of the amount of dissolved oxygen in the water.

Although the use of remote sensing as an air pollution monitoring tool is currently rather limited,[13] research is underway to develop additonal sensors capable of aiding in the task. "While photography proves useful for pin-pointing and confirming locations of air pollutant sources, and for

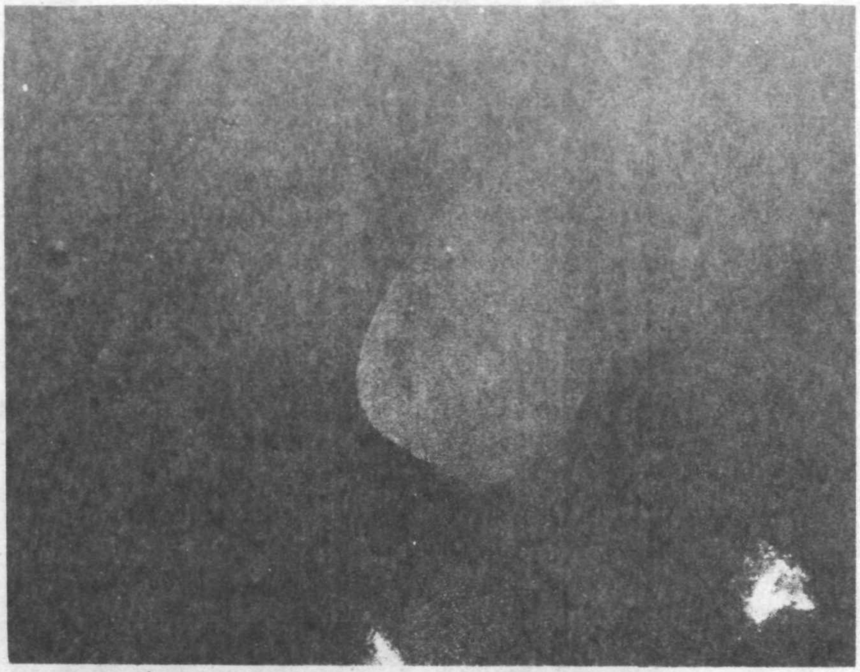

Figure 23. Sewage outfall. The green-brown stains which created this discoloration in the water in Salem Harbor, Mass., stem from a 54-inch outfall under 47 feet of water. Stain discolors more than 4 square miles. (Strandberg)

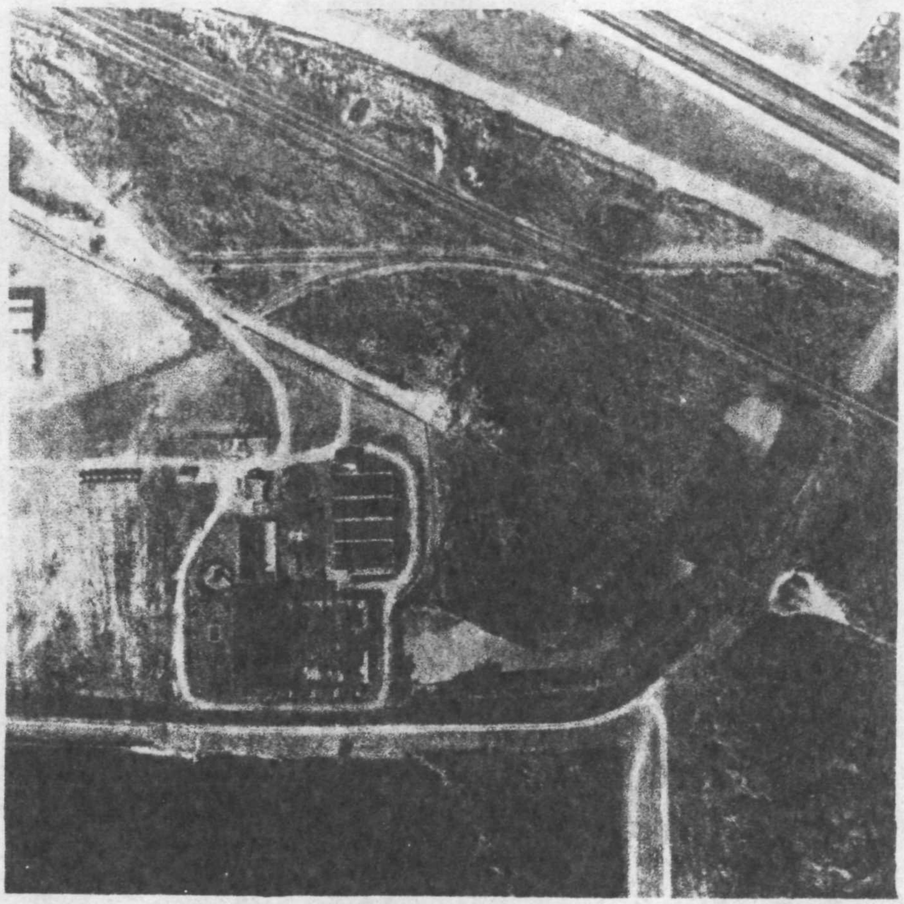

Figure 24. Sewage plant effluent. Color infrared imagery. (NASA Photo)

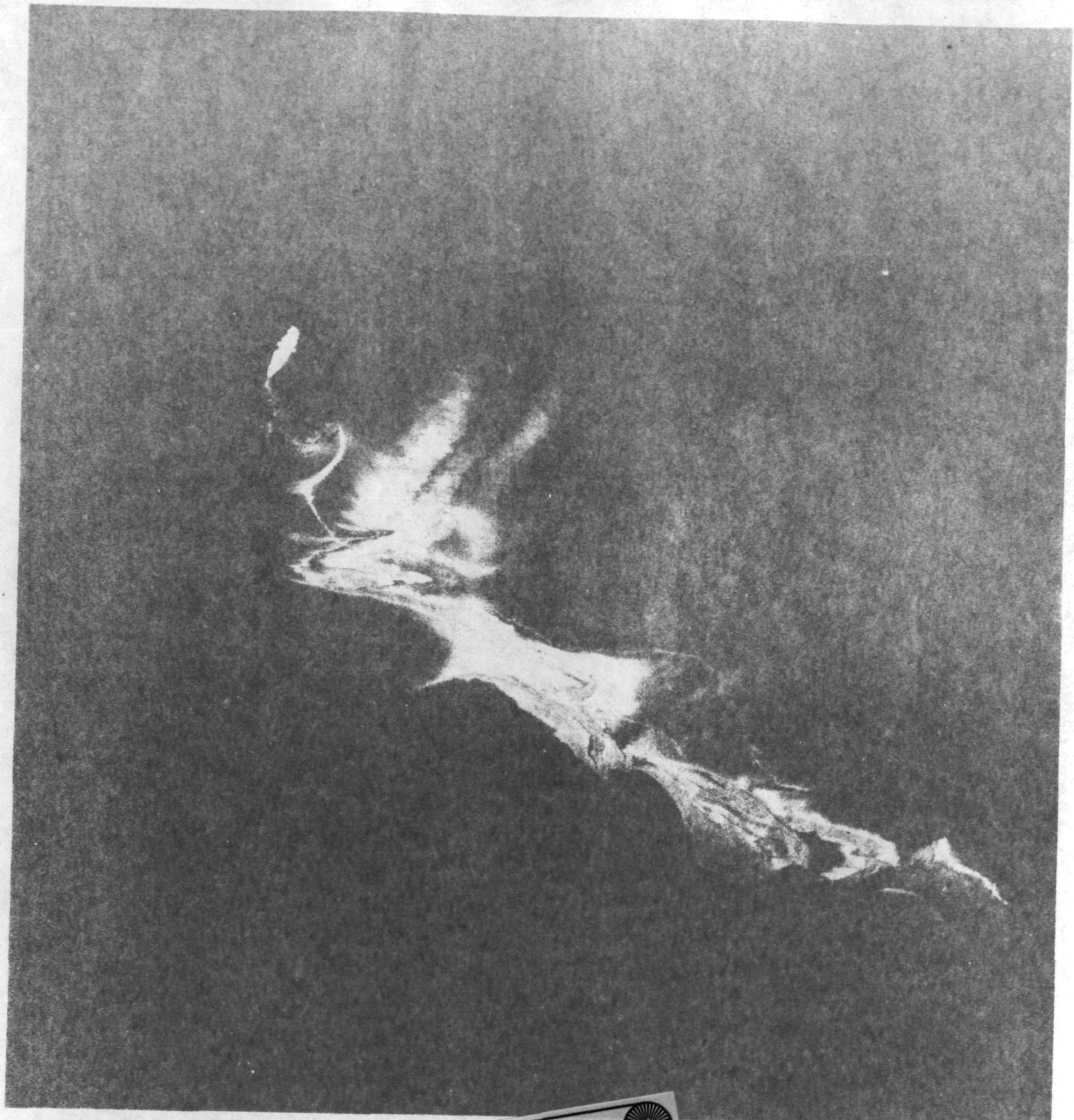

Figure 25. Oil slick. Black and white print of color photograph. (Munday).

Figure 26. Thermal pollution. Infrared image of Taholah, Washington, area showing thermal plume developed off mouth of the Quinault River. (MacLeod)

Figure 27. Algae growth in the Potomac River. (USGS/NASA photo).

identifying offending industries by type, absorption spectrometic data provides a capability for regional quantitative air pollution assessment to determine 1) individual pollution sources, 2) total atmospheric pollutent burden, 3) mass transport of air pollutants across a given line, in conjunction with air-movement data, 4) vertical distribution of pollutants, and 5) rates of lateral diffusion of pollutants. Multiband photography and infrared imagery can also provide data useful for correlating with non-imaging air pollution monitoring systems." (Wobber, p.34).[16]

In regard to water and air pollution, and sedimentation, there are several areas of data acquisition other than monitoring to which remote sensing data can currently make a unique contribution. Among these is an investigation of the patterns of pollution. Use of dyes and color photography can be used in conjunction to yield greater knowledge of currents and deposition mechanisms in areas such as the Potomac Estuary. Turbidity of water can also be examined by remote sensors giving environmentalists additional knowledge on the effects of pollution. Data of this type could provide a basis for a better understanding of the effects of pollution and in turn provide guidelines for combating it.

Patterns of dispersal of air pollution can also be determined with the use of remote sensors, in particular, color vertical and oblique photography, as Veress demonstrates in his article, "Air Pollution Research". (Veress, p. 840).[15] The remote sensing in this case could be used to calibrate meteorological models and to map pollution for quantitative and qualitative analysis.

Remote sensing can also be used for acquiring data for engineering studies and overall system operations surveys. Figures 28 and 29 respectively, illustrate a small sewage treatment plant and a water purification installation within the metropolitan area. Note in Figure 28, one aerator is operating, and in Figure 29, three purification units are in various stages of maintenance.

H. Miscellaneous

One particular application of remote sensing information, that, while falling under several of the headings mentioned above, has specific data needs of its own. This is "siting". Imagery analysis can assist in the specific alignment of a new highway, planning for the delineation of recreation areas, the selection of location or status of a land fill site, and for other similar locational purposes.

Also in addition to the detailed analyses described in the foregoing sections, remote sensing imagery, by adjustments in the scale can be utilized for mosaicking and for representation of general area overview purposes where standard maps, lacking the vigor and timeliness of the photographic image, might not be satisfactory.

Another area of application is in the area of training. The Council of Governments is in a favorable position to provide training support in the form of seminars, traveling briefings, and so forth, and thereby encourage wider use of remote sensing data by regional planning staffs as well as by plannings staffs at the local levels. In this regard,

Figure 28. Sewage treatment plant. Nebasco Creek, Virginia. (Photo Science, Inc.).

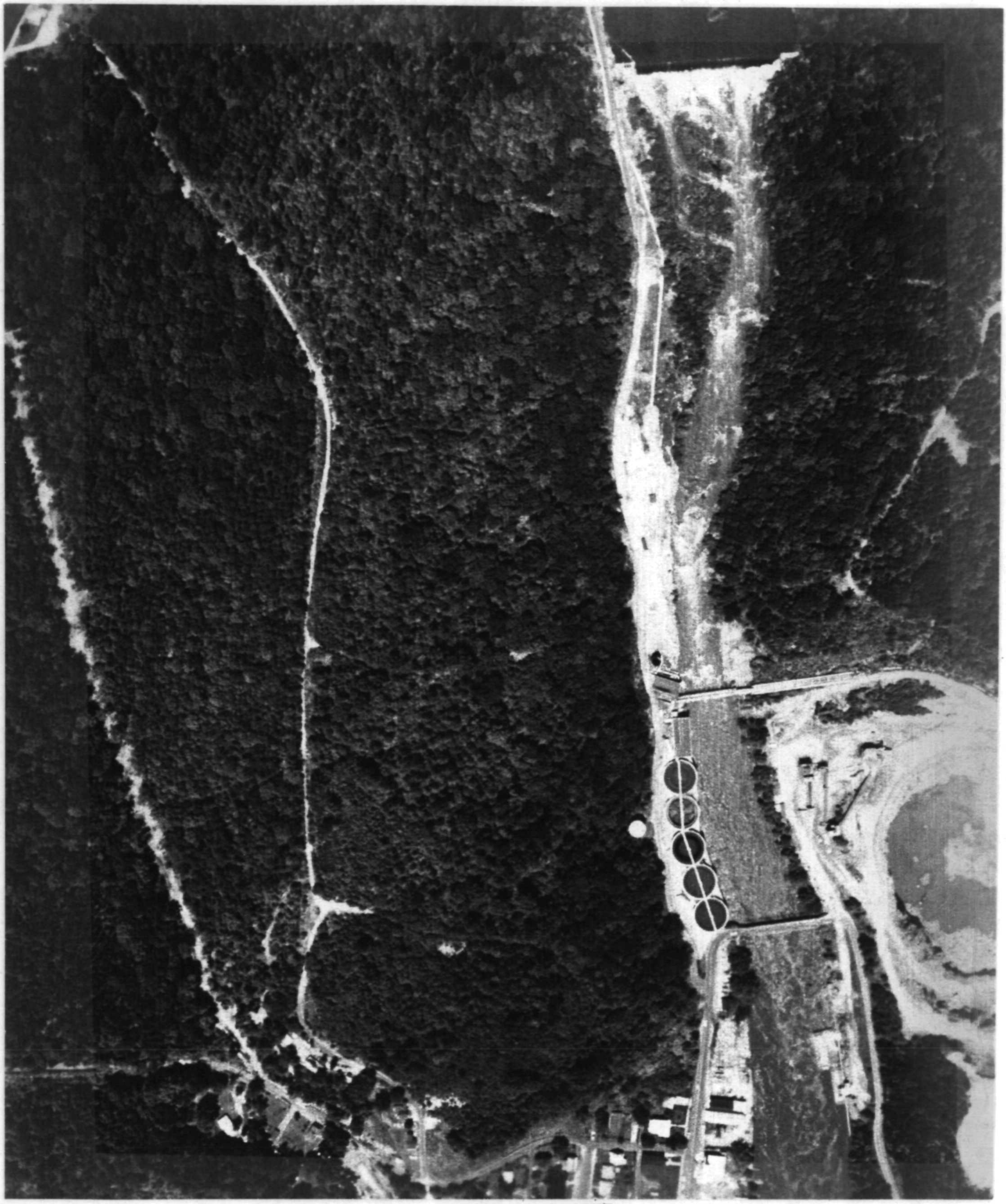

Figure 29 Water purification plant. Occoquan, Virginia.
(Photo Science, Inc.).

COG, by rendering such an additional service, would unquestionably accrue both short and long range benefits to its planning programs.

Applications for remote sensing data in support of public services operations for emergency, rescue, monitorship of possible trouble spots, selection of helicopter landing sites, and so forth, are feasible. Since emergency incidents tend to be localized, for the most part, large scale imagery would be preferable because of greater detail presentation.

Lastly, as an additional service to its member jurisdictions, the Council of Governments, having conducted research on the availability of aerial photography within this region, and having indexed it, is able to provide, on request, current photo information to local planning and analytical staffs and other related user groups within the area. (Mallon and Howard).[11]

TABLE I

LIST OF APPLICATIONS OF REMOTE SENSING TO REGIONAL URBAN PLANNING

Areas of Data of Interest to COG	Applications
Natural Features	Geology, soils, slope, flood plains, natural resource deposits, soil mositure.
Transportation	Traffic volume, patterns, movement, and routing, parking and terminal facilities, effect of safety improvements, siting, mapping, synoptic overview.
Land Use	Improvements of land use data in Council of Governments' parcel file, monitoring areas of change and special interest, updating of regional land use maps, historical growth, siting.
Flood	Flood plains, imperviousness, soil moisture, snow cover, runoff retention monitoring, surface water.
Sedimentation	Location and monitoring sources, transport mechanisms, deposition patterns.
Pollution	Monitor water pollution discharges, water temperature and turbidity, oil spills and fish kills, study transport and deposition patterns, locate of air pollution sources, survey air pollution dispersion, study effluent characteristics, monitor treatment plants.

TABLE I

LIST OF APPLICATIONS OF REMOTE SENSING TO REGIONAL URBAN PLANNING

Areas of Data of Interest to COG	Applications
Housing	Identification of housing stock, location, type and structural character. Detection of environmental conditions suggesting quality and condition of housing and neighborhoods.
Miscellaneous	Siting, training, public safety, and aerial photographic availability.

3. SUMMARY

This paper is probably best summarized and expressed in Table I which identifies major regional probem areas of analytical and planning concern to the Metropolitan Washington Countil of Governments. Matching these are listed a variety of corresponding subject areas of environmental condition, ecological events, status of change, patterns of activity, and so on — in short, the elements associated with a dynamic urbanizing region — to which remote sensing has an application, and can make a contribution as a unique or collateral data source.

The list is varied, as well as lengthy. In some instances, applications of remote sensing data, as described, would provide important inputs to the Council of Governments' information and planning programs, and could provide the principal means of acquiring the data. In other instances it includes applications of the remote sensing data which would have relatively minor data contributions to make or which would be essentially supplemental in nature.

The examination of applications discussed and presented in this report is in the nature of a summary inventory of likely uses of remote sensing data. Those applications offering the most appealing promise of effective utility, such as, for example, land use analysis, change and growth detection, elements of transportation studies, pollution detection and monitorship, training, and photo index services would appear to offer immediate benefits and would suggest serious consideration for in-house operational testing and implementation.

For other types of applications such as those dealing with natural features (geology, hydrology, topography, etc.) for which basic remote sensing analysis is used, reliance, because of specialized staff and equipment requirements, must continue to be placed upon those appropriate Federal and State agencies responsible for such analyses and associated end products.

In those areas involving current research by other investigators in government and elsewhere who are testing the capabilities of remote sensing data for the determination of specific quantitative relationships in such problem areas as air and water pollution and sediment transport mechanisms, efforts should be made by this organization to maintain contact with and to monitor the progress of these research programs, especially as they have application to this region.

In both instances, however, in order to provide data needed for current, "crash", interim, or other COG planning or study information requirements, opportunities, we believe, would frequently present themselves for a task-oriented, in-house imagery analysis effort — even one of limited scope.

Finally, it is of some importance at this time that the COG Departments maintain the level of interested inquiry initiated by this study series in the examination of their planning program data needs as might supported by remote sensing data. It is of particular importance that this level of interest be maintained and that some implementation be initiated in order that these applications may have opportunities for further testing during 1972 with the advent of imagery of this region from NASA's Earth Resources Technological Satellite (ERTS-A) and the USGS's Earth Resources Observation System's (EROS) data handling and analysis program.

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16. Abstracts

A comprehensive inventory of a series of applications to which remote sensing data may be beneficially applied for use in a variety of regional planning programs of concern to the Metropolitan Washington Council of Governments has been undertaken in this study. Examples of application, methods for data utilization and corresponding photographic illustrations are provided illustrating how remote sensing would prove particularly useful as a unique and/or supplemental data source.

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